Technology Based Solutions for Process Management in Aviation Maintenance

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ABSTRACT

A prototype electronic data management / product data management (EDM/PDM) software system was created using off-the-shelf software. The system was designed to replace the current manual process of service order work instruction deck creation at a large aircraft maintenance station. Results of the evaluation showed the potential for a savings of approximately 32 person-hours (80%) per service order in the planning stage alone. The current process requires an average of 40 person-hours while the prototype electronic process requires an average of eight person-hours.

INTRODUCTION

The aircraft maintenance system is a highly complex one consisting of several human and machine components. Currently, the large portion of the aircraft maintenance workflow is controlled through such written documentation as work card instructions, manuals, airworthiness directives, and non-routine work instructions. The current system presents numerous opportunities to implement interventions to make the system more effective, efficient, and reliable. Reduced funding, shorter schedules, and increased competition have created a need for achieving maximum efficiency without compromising safety. At every stage of the maintenance cycle, data is generated, but only when the required data arrives at the right place at the right time does it improve efficiency. With the advent of "enterprise-wide" electronic data management (EDM) systems, industry now has the opportunity to effectively control its information, eliminate the proliferation of redundant data, and accommodate shorter life cycles. These opportunities can be realized while simultaneously raising quality and reducing costs.

PDM, a derivative of Electronic Data Management and electronic workflow, was specifically designed to address the demands and requirements of process-driven industries such as manufacturing and maintenance. Thus, PDM is intended to reduce error rates, improve regulatory compliance, accelerate turnaround times/product cycles, and lower costs.

The literature reports several successful case studies in the implementation of PDM to improve workflow in non-aviation environments (Atkinson & Glasscock, 1990; Bryan, 1997; Bowman, 1996). Despite the successful use of PDM in non-aviation environments, its use in aviation, and specifically for maintenance, is not yet on a sufficient path to reach its full potential.

In response to this need, the Federal Aviation Administration (FAA) Aviation Maintenance and Inspection Human Factors Research Program looked at the applicability of PDM/EDM in aircraft maintenance. As part of this research, Galaxy Scientific Corporation assessed the extent to which off-the-shelf EDM/PDM software could be applied to aircraft maintenance tasks (Millians, et al., 1999). The tasks include the following: controlling updates to manuals, regulations, and other written documentation; managing information transfer; improving completeness and accuracy of information entered on forms; making reference information more readily and rapidly available; and expediting lookups, cross-references, etc. The research was conducted in cooperation with a major US aircraft repair station to demonstrate the applicability of EDM/PDM in the aviation maintenance environment. The research called for an in-depth task analysis of the entire maintenance process, from service order scheduling to final release. Measures included such requirements as:

- Time, cost, infrastructure, and services,
- Worker acceptance of process automation,
- The readiness of the environment for technology-based solutions including whether the documents were in electronic format, the workflow sufficiently defined, and computer equipment in place or in use,
- The overall viability of implementing PDM,
- The probable results of implementing PDM in an aviation maintenance environment.

In summary, the specific objectives of the research were:

- To review the applicability of off-the-shelf PDM software in the aircraft maintenance environment.
- To develop a prototype PDM system demonstrating the possible improvements in effectiveness and efficiency for a representative aircraft maintenance process.

PDM BACKGROUND

The history of PDM itself can be traced back several years. PDM has evolved over two distinct phases: EDM (Electronic Data Management) and PDM (Product Data Management). EDM products satisfied relatively simple requirements by enabling secure management of an organization's computer automated drawing (CAD) data on a single system. PDM extended the data management capabilities of EDM systems to cover data from the

manufacturing stage as well as the design stages of a product's life cycle. Thus, the term PDM, which has come to describe the enhanced capabilities of these systems, supports the entire product life cycle and the management of a wide variety of data.

In the early 1980's, large corporations found their progress seriously hampered by paper-based systems. Hence, they tried to develop solutions internally, as no commercial systems were available. In the early 1990's, several software companies, realizing the need and associated business opportunity for such a product, introduced the first generation commercial off-the-shelf PDM systems. The basis of these PDM systems is the database engine on which are stored records of parts and related files. PDM involves collecting, managing, and disseminating all data about a product's whole life cycle from design to decommissioning. Thus, PDM technology is used to manage product-related information and processes. The challenge for PDM is to maximize the time-to-market benefits of concurrent engineering while maintaining control of data and distributing it automatically to the people who need it when they need it. The way PDM systems cope with this challenge is by holding master data only once in a secure "vault" where its integrity can be assured and all changes to it monitored, controlled and recorded (see Figure 1). Duplicate reference copies of the master data, on the other hand, can be distributed freely to users in various departments for design, analysis, and approval. The new data is then released back into the vault. When a "change" is made to data, a modified copy of the data is signed, dated, and stored in the vault alongside the old data, which remains in its original form as permanent record. This is the simple principle behind today's advanced PDM.

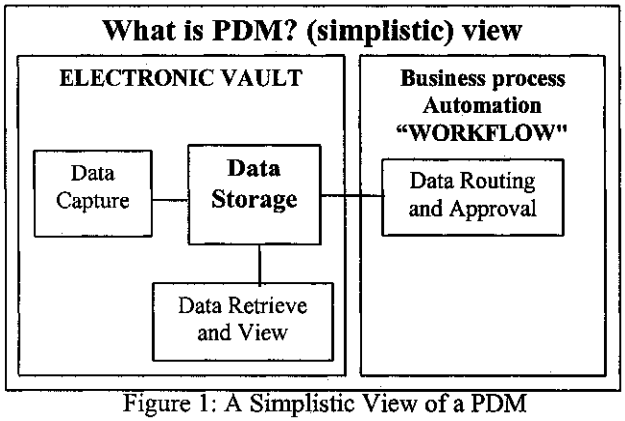

Figure 1: A Simplistic View of a PDM

Companies have realized the numerous benefits of implementing PDM. First, they save money because of improved productivity and reduced waste. All versions of all data are located in the software system. This data storage capability aids in paper trail audits as well as version control. Second, the data storage improves ability to find correct data quickly. Most of the software systems include the capability to not only search for documents, but also to search within documents. Third, the EDM/PDM software system improves process and workflow. Because the process follows a predetermined workflow, it will be near impossible to skip or forget procedural steps within the workflow. This is because, fourth, software improves integrity, tractability, and auditability of processes and data. All procedural steps are tracked and all changes are noted. The software serves as a governor of the process. And last, EDM/PDM software systems improve change management and configuration management processes.

The key issue in developing a PDM strategy involves creating and manipulating the product data by looking at all stages of the life cycle including inputs and outputs, data travel, data use and technology. Key factors for successfully implementing PDM are an empowered staff and the willingness to engage all disciplines in the design process right from the start. In addition, the use or existence of function and product-oriented teams, co-location for all design disciplines, state-of-the-art computer tools, appropriate and timely staff training, concurrent development and review of all product data, and unwavering management support will lead to success.

PDM IN AIRCRAFT MAINTENANCE

The prototype software used a customized version of an "off-the-shelf" document management software program called NovaManage. This software was chosen because of its highly customizable characteristics. The researchers customized NovaManage for the specific needs of the research partner's planning department.

The PDM/EDM software was developed in a modular fashion with different levels of access and authorizations. The access levels determine the degree of authorization, which, in turn, establish the degree of control available to the different users having access to the system. The development of the PDM software followed the classic iterative development methodology. The software was designed as a "proof of concept" approach to demonstrate the use of an electronic documentation tool in the aircraft maintenance environment. As such, the software is only a prototype for studying the effects of electronic documentation for a representative process in the aircraft maintenance industry. Another purpose is to demonstrate the effective use of off-the-shelf software for the implementation of EDM/PDM functionality into existing task flow architecture.

A TEST BED FOR PDM

We selected a representative process from the aircraft maintenance environment to demonstrate PDM. The specific process selected was "creation of work instruction cards for use on the hangar floor. The researchers created the software prototype for the Planning Department to automate the tasks associated with work deck creation.

WORK CARD CREATION: TASK DESCRIPTION

Simply stated, a work card instruction identifies the series of steps that must be taken by the technician and/or inspector so that work adheres to mandated procedures. Before the instructions can be made available to the hangar floor, they are

assembled and passed through a series of approvals. The existing process for work card creation is essentially a manual one that is generated and accomplished by the Planning Department.

At the representative aircraft repair facility, a set of work card instructions has to be put together for each service order for each aircraft. Each order (scheduled maintenance appointment) consists of from one to more than fifty work instructions, each of which includes references to the aircraft maintenance manual, graphics, parts lists, and check-out cards. Following its creation, the service order is routed for approval through the appropriate authorities – the customer and the quality assurance personnel. At each step of the approval process, the work card instructions are reviewed, approved, and forwarded to the next stage for processing. Once the entire deck is approved, it returns to the planner where it resides, ready for distribution. Creation of a complete work card deck (all of the work instructions for a given service order) currently requires up to forty person-hours. Table 1 compares the time required for traditional methods with the time for the EDM system.

	Traditional	With EDMS
Receive Tail Number and Work Request from Customer		
Customer calls with Tail Number and Work Request		
PD Looks up Serial Number	Manual	Automatic
PD Sends Information to Finance Dept.	Manual	EDMS Work Flow
Receive Bar-code Number from MIS		
PD receives Bar-code number via modem	Manual	EDMS Work Flow
PD receives Bar-code number via modem	Manual	Automatic
Create Work Card Stack		
Look up Work Card by Work Instruction No.	MS Word	EDMS Search
Enter Serial No. And Tail No. On Work Card	MS Word	Automatic
Append References to Work Card	Manual	Automatic
Search - Find references on Micro-fiche	Manual	Eliminated
Print copy of reference	Manual	Eliminated
Append graphics to Work Card	Manual	Automatic
Count the number of required graphics	Manual	Eliminated
Print blank work card pages equal to number of graphics	Manual	Eliminated
Make copy of graphics from service manual on Xerox	Manual	Eliminated
Tape or glue graphics to blank work card pages	Manual	Eliminated
Make copy (Xerox) of new page	Manual	Eliminated
Approve Stack		
Send stack to QA	Manual	EDMS Work Flow
QA Stamps approval	Manual	Digital
QA sends stack to PD	Manual	EDMS Work Flow
Deliver to Maintenance Floor	Manual	EDMS Work Flow
TOTAL TIME	**32-40 hrs**	**8 hrs** (estimate)

Table 1: Task outline

THE WORK CARD CREATION PROCESS

The Manual System

The operation sequence begins when a customer schedules an aircraft for maintenance. At the outset of this project many of the work cards were assembled with a mix of digital and hardcopy documents. The documents were, literally, taped or glued together, for photocopying. The system worked but it was time consuming.

The PDM System

With the proposed software, all steps can be accomplished at the computer. For research purposes, two major assumptions were made. First, we assumed that all relevant documents are available in an electronic format. The second assumption deals with intranet or client / server connectivity. Because the software includes workflow processes requiring the participation of many offices, to use the prototype software properly and effectively, a network must exist. These assumptions presented extensive challenges.

The planning process begins with the creation of a service order. Figure 2 shows representative screens viewed by the user in creating the work deck. Within the software, a service order is an entity containing all the necessary documents. A window appears along with a list of the folders (directories) containing the necessary documents. The work cards, listed by number and revision, are then "dragged and dropped" into the service order window. Following this step, the software generates a bar code on each work card. An electronic work flow is chosen by the planner from a list of workflows in the system. Once the process is started the next person listed is notified via email to enter the system and check the deck

online. Upon approval, the person simply presses a "Stamp" button and enters a password to allow the deck to proceed to the next step. After all parties have approved the deck, it is sent electronically to the hanger floor.

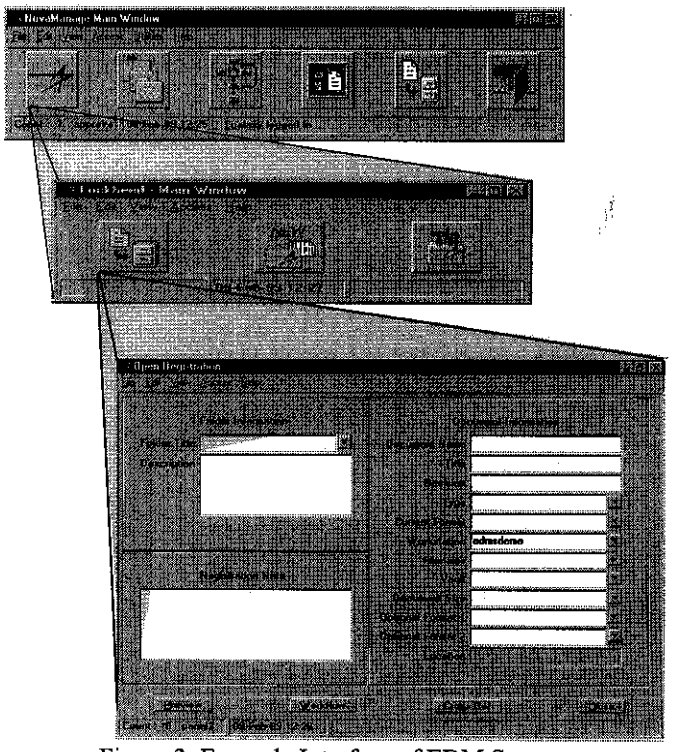

Figure 2: Example Interface of EDM System

SYSTEM EVALUATION

We demonstrated the completed prototype EDM system to the Planning Department at the research partner's facility. Senior planners used the system, after which they completed a questionnaire evaluating the EDM system. The participants answered questions relating to usability and usefulness of the system.

The analysis, though limited in sample size, reveals that the system, if converted into a fully usable system, has the potential to make the existing process highly effective and efficient. The average time for work card generation and approval process could be reduced from the existing 40 person-hours to eight person-hours. This can be very significant for an airline looking for costs savings or reduction in labor hours. Other major advantages of using such a system are:

1. Improved accuracy and integrity in the process
2. Secured data transfer
3. Electronic approval process
4. Superior record keeping and detailed record in history of updates
5. Different levels of access based on user types
6. Portability
7. Ease in integration with other systems (e.g., person-hours worked on job, tracking job status)

The system also scored high on usability and interface design issues, which is a testament to the methodology employed in the development of the prototype system. Responses indicated that the planners preferred the new system to the existing system on all the issues.

While the users rated the system highly, the task of implementing EDM/PDM in the aircraft maintenance environment will not be an easy one. Major barriers must be overcome to implement a PDM based solution. Realizing the existence of these barriers and knowing potential interventions is an important first step. The major barriers/issues to implementing PDM in the aircraft maintenance environment are the following: Organizational Culture, System Integration, Training, and Corporate Commitment to Implementation.

CONCLUSIONS

This research demonstrated the successful implementation of a prototype EDM/PDM system for a representative aircraft maintenance process. The research project showed that a PDM- based solution improved the effectiveness and efficiency of a specific process in the aircraft maintenance environment over an existing manual system. This in turn has direct impact on improving the safety and reliability of aircraft maintenance operations. The research also showed that commercial off-the-shelf software PDM solutions can be developed fast and at a reasonable cost. The relatively low cost of COTS PDM/EDM software will enable aircraft maintenance organizations with limited budgets, to implement PDM based solutions. Once implemented correctly, PDM solutions have the potential to improve the integrity of various aircraft maintenance processes and ultimately aviation safety.

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